Sensitivity of Airburst Damage Prediction to Asteroid Characterization Uncertainty

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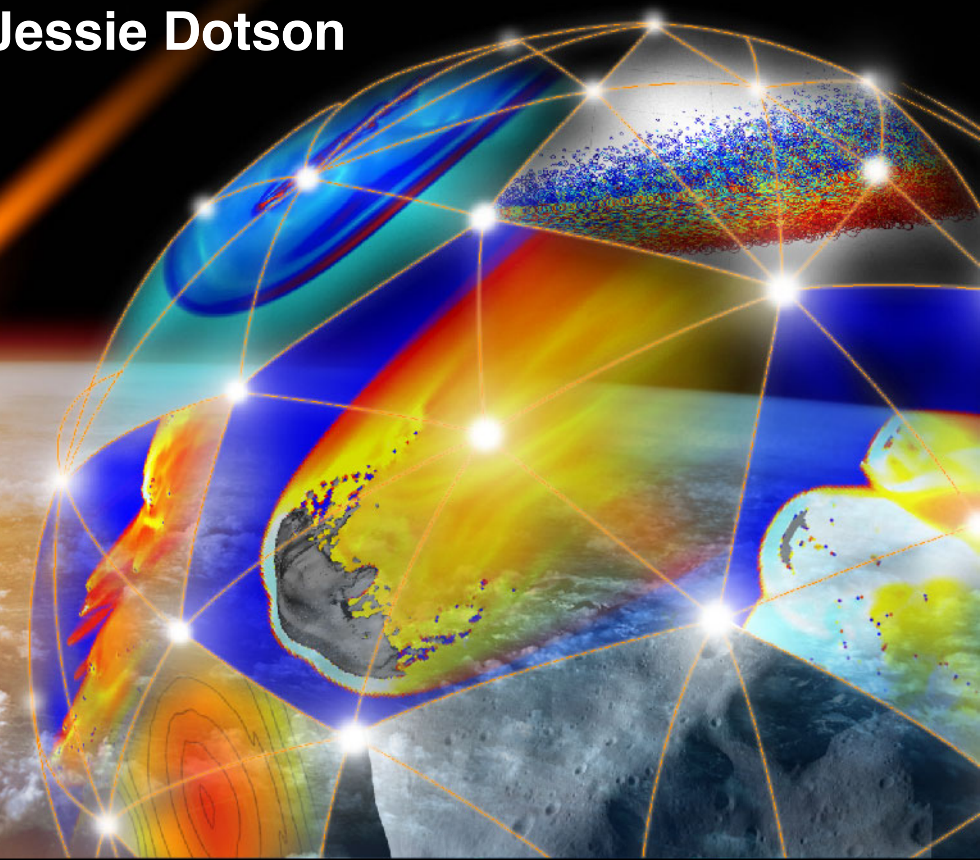
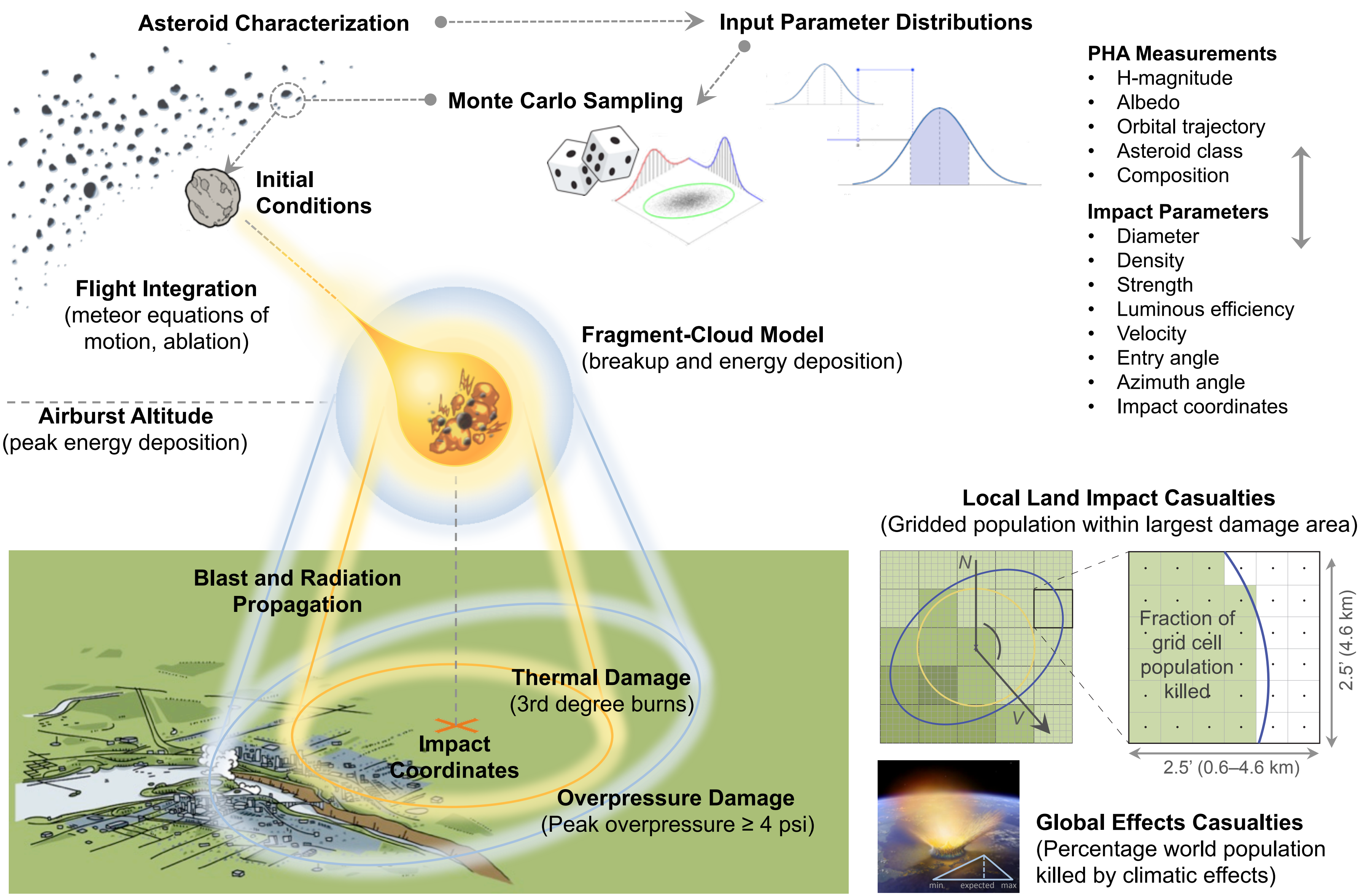


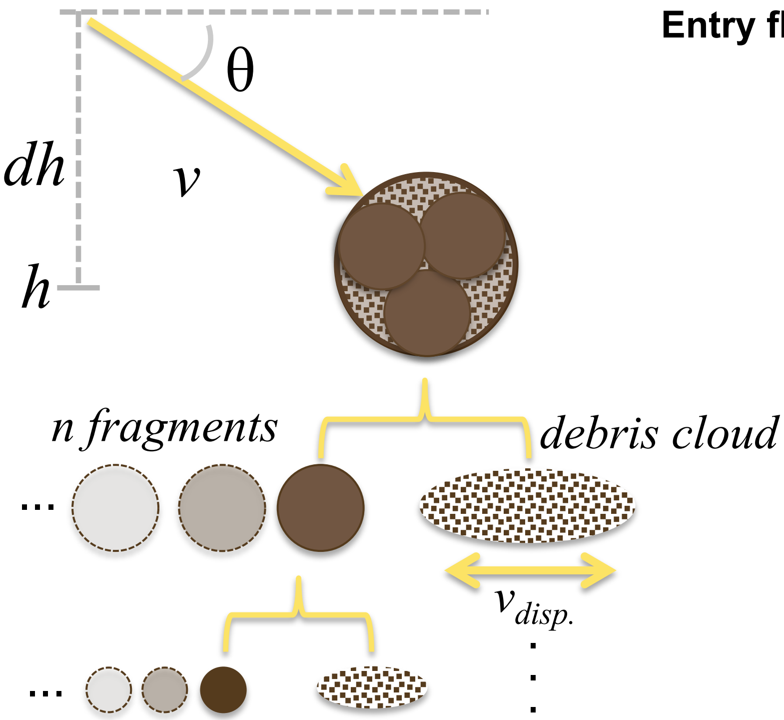
DPS48, Pasadena, CA
October 19, 2016

Physics-Based Impact Risk Model



Fragment-Cloud Model (FCM)

- Analytic model of asteroid entry/breakup to estimate energy deposited in the atmosphere
- Combines progressive breakup of independent fragments and “pancaking” debris clouds.



Entry flight: integrates meteor equations of motion and ablation

$$dm/dt = -0.5\rho_{air}v^3A\sigma$$
$$dv/dt = \rho_{air}v^2AC_D/m - g\sin\theta$$
$$d\theta/dt = (v/(R_E+h) - g/v)\cos\theta$$
$$dh/dt = v\sin\theta$$

Fragmentation when pressure > strength

$$\rho_{air}v^2 > strength$$

Each break yields:

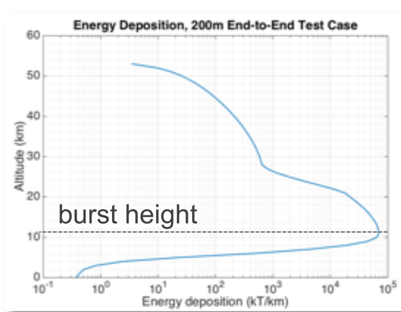
- Multiple independent, identical fragments (baseline 2)
- Debris cloud of specified mass fraction (baseline 50%)

Fragment strengths increase with decreased size

$$S_2 = S_1(m_1/m_2)^\alpha$$

Clouds broaden and slow under common bow shock

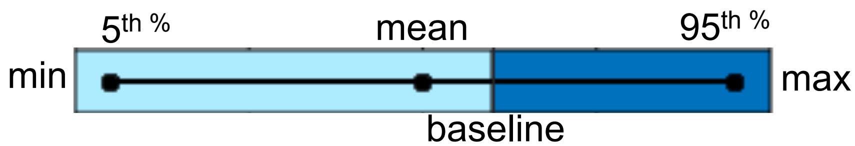
$$v_{dispersion} = v_{cloud}(3.5\rho_{air}A/\rho_{cloud})^{1/2}$$

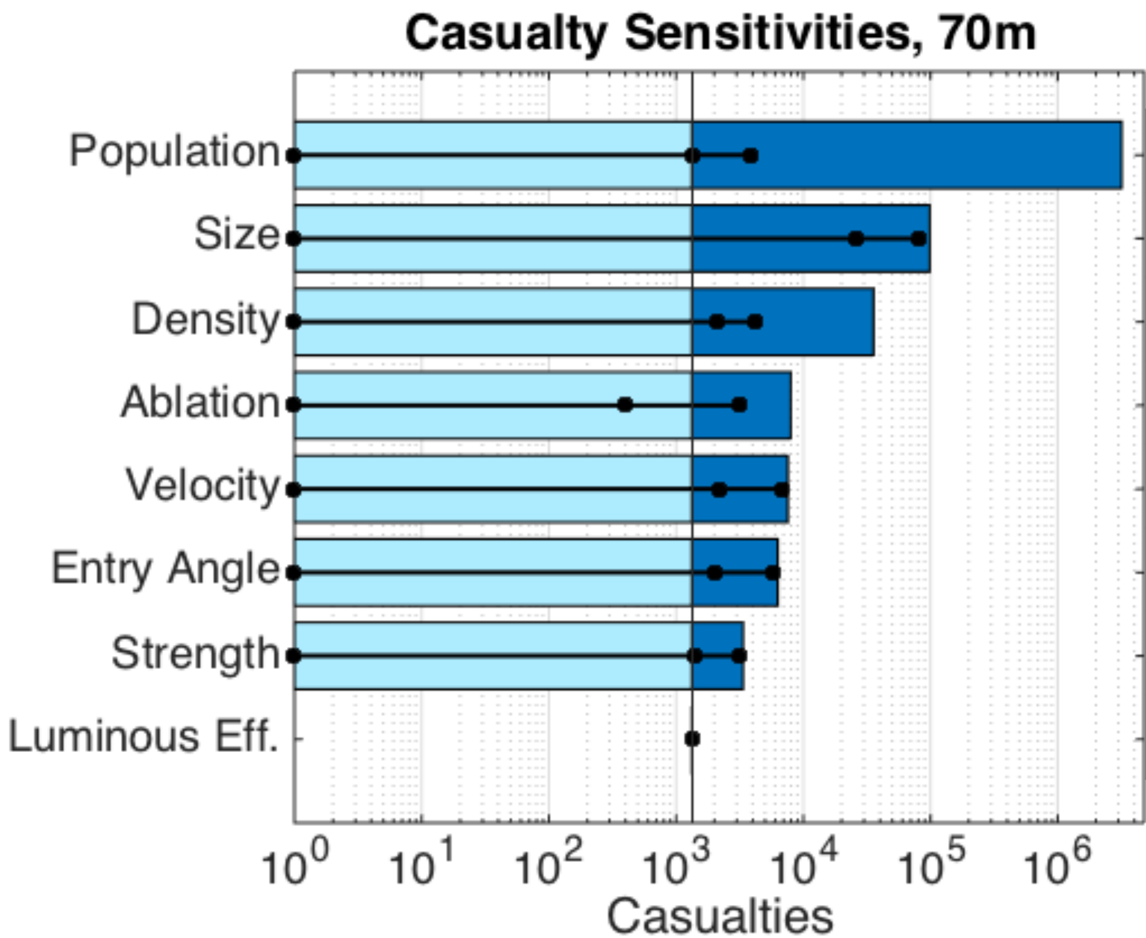


Energy deposition computed as change in total KE of all fragments/clouds as a function of altitude.

Airburst at altitude of peak energy deposition.

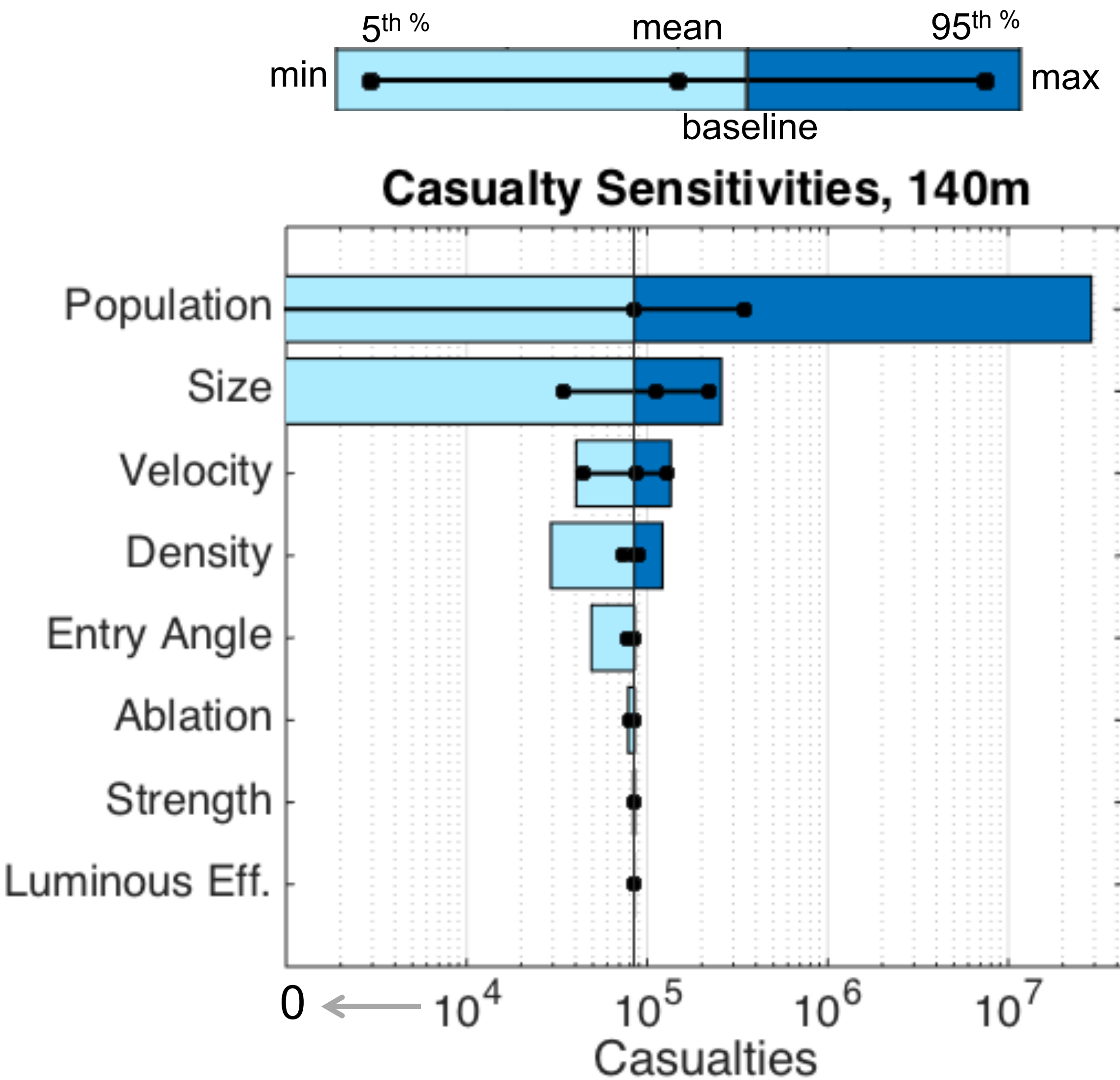
Sensitivity to Parameter Variations, 70m Diameter





Baseline	Variation
Avg. pop.	Local gridded pop.
70m	H-mag 23.5 (~30-150m)
3400	Meteorite distribution
1e-8	1e-9 – 1e-7 (uniform)
21	12 – 30 km/s (uniform)
45°	0° – 90° (weighted)
5.05	0.1 – 10 MPa (uniform)
0.03	10^{-4} – 10^{-2} (uniform)

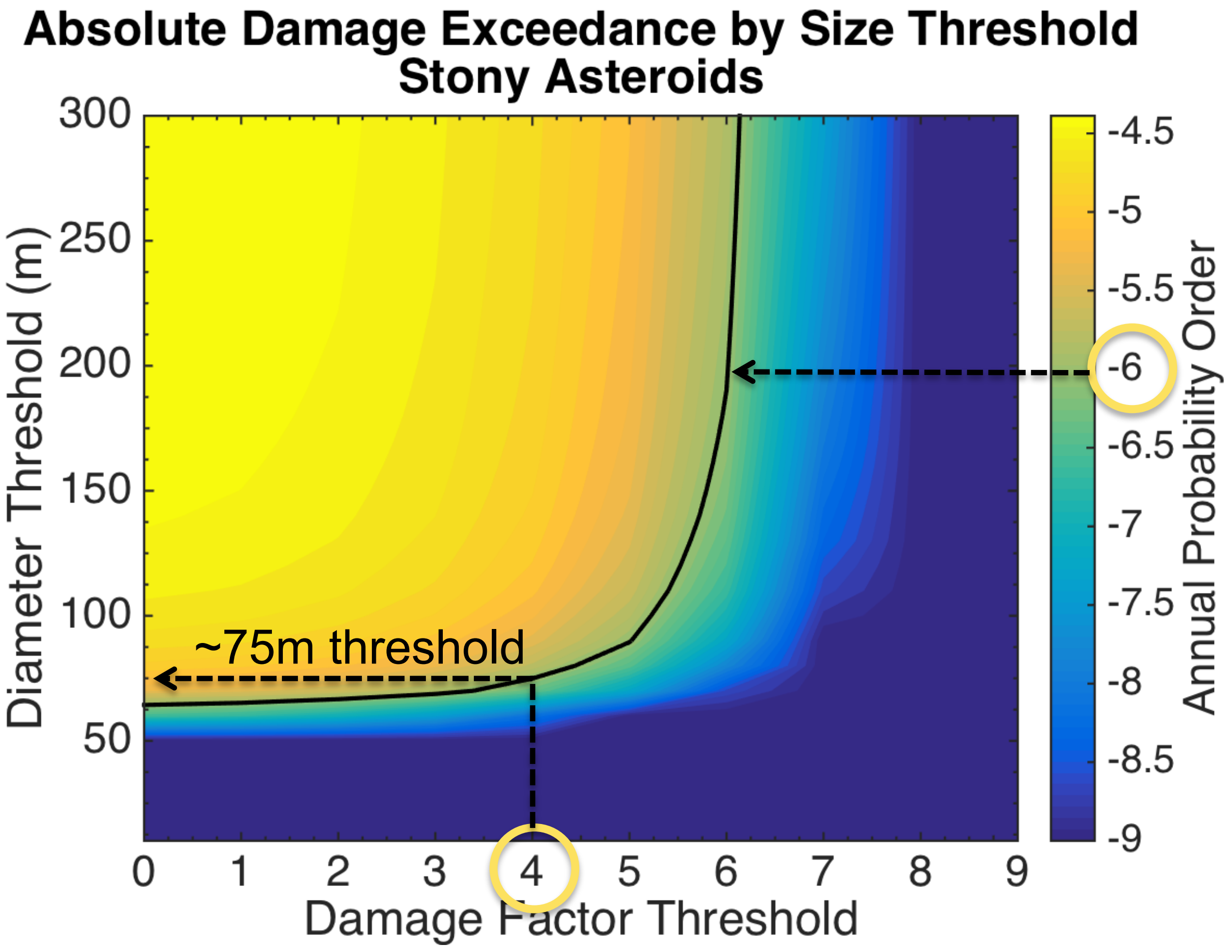
Sensitivity to Parameter Variations, 140m Diameter



Baseline	Variation
Avg. pop.	Local gridded pop.
140m	H-mag 22 (~65-310m)
3400	Meteorite distribution
1e-8	1e-9 – 1e-7 (uniform)
21	12 – 30 km/s (uniform)
45°	0° – 90° (weighted)
5.05	0.1 – 10 MPa (uniform)
0.03	10^{-4} – 10^{-2} (uniform)

Impact Risk Distribution

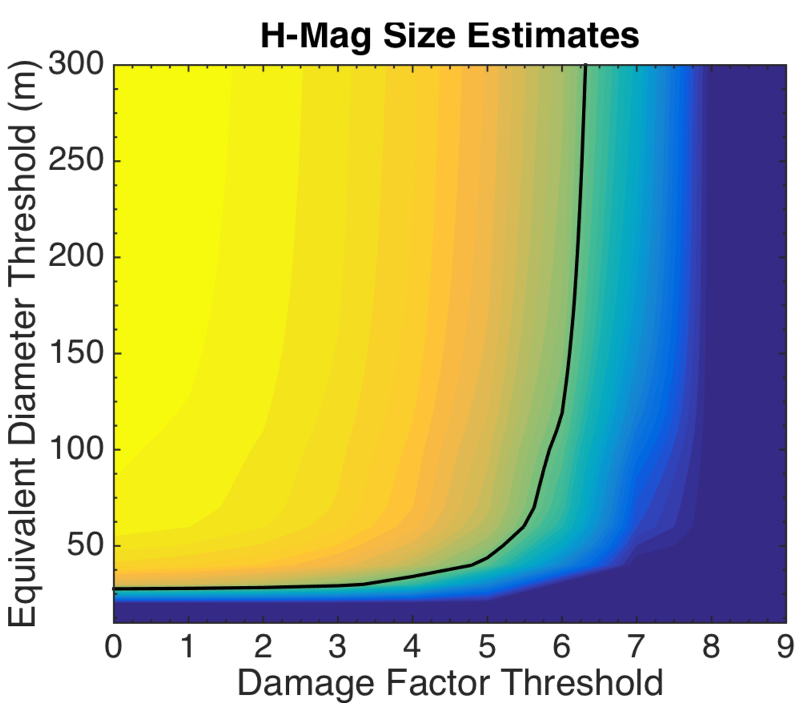
- Sample risk posture: track any size with at least a one-in-a-million/year chance of causing damage above a threshold level of 4 (10^4 affected people).



Absolute Size & Damage Thresholds

- Damage threshold pushed to smaller H-magnitude equivalent diameters, driven by potential for actual asteroid to be larger than assumed from average albedo conversion.
- For sizes that tend to cause little-to-no damage, potential to be larger than assumed has greater risk impact than potential to be smaller.

H-Mag Size



Direct Diameter